Strategies to Protect the Health of Deployed U.S. Forces

Detecting, Characterizing, and Documenting Exposures

Thomas E. McKone, Beverly M. Huey, Edward Downing,
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Strategies to Protect the Health of Deployed U.S. Forces:
Technology and Methods for Detection and Tracking of Exposures
to a Subset of Harmful Agents

Division of Military Science and Technology
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STRATEGIES TO PROTECT THE HEALTH OF DEPLOYED U.S. FORCES
Technology and Methods for Detection and Tracking of Exposures to a Subset of Harmful Agents

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Preface

Since Operation Desert Shield/Desert Storm, Gulf War veterans have expressed concerns about health effects that could be associated with their deployment and service during the war. Although similar concerns were raised after other military operations, the Gulf War deployment focused national attention on the potential, but uncertain, relationship between the presence of chemical and biological (CB) agents and other harmful agents in theater and health symptoms reported by military personnel.

A number of studies have addressed the issues of veterans' health and the potential health effects of their service, focused mostly on understanding the current health of veterans, ensuring that they are receiving appropriate evaluation and care, and determining the connections between veterans' current health status and service in, and specific exposures during, the Gulf War. As a result of these studies, the U.S. Department of Defense (DoD) has begun to focus more on better monitoring and control of exposures to multiple harmful agents.

Responding to this need, the DoD Office of the Special Assistant for Gulf War Illnesses, through the National Academies, sponsored Strategies to Protect the Health of Deployed U.S. Forces, a study that consists of four two-year studies followed by a consensus study. At the end of the second year (November 1999), the four study groups are issuing reports to DoD and the public on their findings and recommendations. These reports will then be used as a basis for a consensus study by a new National Academies committee in the third year of the project. The consensus committee's report will include the issues raised in the four

two-year studies, as well as overarching issues relevant to its broader charge.

This report, which is one of the four two-year studies, examines the detection and tracking of exposures of deployed personnel to multiple harmful agents. Unlike most National Academies studies, which are conducted by a committee led by a chair, this study was conducted by a principal investigator who was supported by a panel of technical advisors. As principal investigator, I worked with the National Research Council (NRC) staff to identify potential advisors, collect and synthesize data and information from relevant sources, and prepare this report, including its conclusions and recommendations. The members of the technical advisory panel participated in the report development process and the planning and management of workshops, the commissioning of papers, and gathering of information.

During this study, the panel, staff, and I received numerous briefings, visited facilities, consulted with experts, solicitated commissioned papers, attended symposia, and reviewed the open literature. Relevant sources of information used in this study include reports and databases from regulatory and research organizations, as well as information from experts in relevant disciplines. We visited and/or were briefed by individuals from numerous organizations, including the U.S. Army Soldier and Biological Chemical Command (SBCCOM), the U.S. Army Chemical School, the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM), the U.S. Army Center for Environmental Health Research (CEHR), and Brooks Air Force Base Crew Systems Division. Five meetings were held: one in March 1998 and one in August 1998, both at the NRC in Washington, D.C.; one at Woods Hole, Massachusetts, in September 1998; and two at the Beckman Center in Irvine, California, one in December 1998 and one in April 1999. A workshop was held in January 1999 at the NRC in Washington, D.C. At each meeting, the principal investigator, advisory panel members, and NRC staff attended presentations of technical information related to specific issues, were given briefings by DoD experts, and discussed key issues with invited participants.

The overall purpose of this study (discussed in Chapter 1) was to assess current and potential approaches to detecting and tracking exposures of deployed military personnel to a number of harmful agents. These agents include CB warfare agents, as well as environmental contaminants, such as hazardous air pollutants, soil contaminants, pesticides, particulate matter, fuels, metals, and microbial agents. This assessment also includes an evaluation of the efficacy and extent of implementation

of current military policies, doctrine, and training. Based on this evaluation, opportunities are identified for adjusting or augmenting strategies to improve the protection of military personnel in future deployments.

From the very beginning of this study, it became apparent that characterizing troop exposures requires many different types of information, as well as information collection and storage technologies. The focus of this study is on the overall practice of collecting, managing, and using information on potential exposures to deployed forces. The study addresses not only detection, monitoring, and tracking technologies, but also the framework in which these technologies are applied.

Understanding exposure requires knowing (1) which agents to look for; (2) whether, in what medium, and at what concentrations they were detected; (3) the space and time distribution of agent concentrations; and (4) the space and time distribution of the troops at risk. Tracking individuals and their exposures over time and space requires methods of determining and recording time-specific locations, detectors, and monitors, as well as methods of assessing harmful agent concentrations and environmental exposure pathways, including meteorological conditions over a wide area and, sometimes, groundwater-flow vectors. Detecting, monitoring, and tracking exposures of deployed forces to multiple agents requires making decisions with multiple, often competing, objectives. In response to a critical situation, the requirements for new equipment and monitoring must be defined and ranked according to the value of the information they will provide.

This study was completed with the full and timely cooperation of the DoD. Our requests for information were quickly and thoroughly answered. This made our work easier and our findings more credible. The members of the advisory panel and I were impressed with the level of research and development, training, and application that DoD is currently devoting to the issues addressed in this report. In fact, the rapid pace of change made it necessary for us to update and revise our findings continually, and many of the issues raised in this report may be resolved before the report has been widely circulated.

The report was refined and improved by reviewers both on the National Academies' staff and external to the Academies. Their thoughtful and constructive comments significantly enhanced the quality of the final report.

Finally, I gratefully acknowledge the work and support provided by NRC staff members: Beverly Huey, the NRC study director for this project, whose dedication, intelligence, and enthusiasm were invaluable; Jack

Downing, who spent long hours editing and revising initial drafts; Ray Wassel, who assisted in the development and preparation of this study; Norm Haller, who served as technical consultant; and Laura Duffy, who helped organize the multiple sources of information and was particularly adept at finding information resources on the Worldwide Web.

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Strategies to Protect the Health of Deployed U.S. Forces: Technology and Methods for Detection and Tracking of Exposures to a Subset of Harmful Agents

Acknowledgments

We are appreciative of the cooperation we received from the many individuals and organizations who provided us with valuable information and guidance in the course of our work. First, we extend our sincere thanks to the members of the advisory panel who provided assistance and guidance during the information-gathering process, gave thought-provoking presentations in their respective areas of expertise, participated in briefings from various organizations, and provided thoughtful comments on the initial drafts of this report. We are deeply indebted to those individuals who prepared commissioned papers for our use and who gave presentations at the January workshop: COL Mike Brown, on predeployment operational decision making; Roy Reuter, on a situational framework for future deployments; Detlof von Winterfeldt, on dimensions of harm; Don Stedman and Murray Johnston, on the analysis of chemical detection technologies; Linda Stetzenbach, on the analysis of biological detection technologies; Peggy Jenkins, on strategies for tracking people; Michael Lebowitz, on tracking exposures; Keith McDonald, on GPS technologies; and Robert Spear, on GPS applications.

We are grateful for the guidance and support of others at the National Academies, including Joseph Cassells and Suzanne Woolsey, who assisted in the coordination of the four studies as they were being conducted simultaneously; Bruce Braun, who assisted in defining the scope of the study and provided ongoing oversight; and Douglas Bauer and Dennis Chamot, who adeptly dealt with stumbling blocks and provided

thoughtful insights. We also appreciate the work of Andre Morrow and Pamela Lewis, who provided administrative assistance in preparing this document for review and publication, and Carol Arenberg, who edited this document for technical content and clarity. Finally, we are indebted to numerous other National Research Council staff: Mike Clarke, associate division director; Margo Francesco, staff associate; Delphine Glaze, Tracie Holby, and Jacqueline Campbell-Johnson, senior project assistants; and Alvera Wilson, financial associate.

The extensive contributions and thought-provoking comments freely given by so many individuals throughout the course of this study enabled us to complete our task. We would like to acknowledge individuals who provided briefings, prepared commissioned papers, arranged site visits to their organizations, gave presentations at the workshop, supplied invaluable information and reports critical to our charge, answered our searching questions honestly, and assisted us in contacting other sources who could provide additional information and documentation. No doubt the list is incomplete, and we apologize for any oversights (see Appendix F).

This report has also been reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the authors and the National Research Council in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The content of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

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Box, Tables, and Figures

BOX

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Abbreviations and Acronyms

AC	hydrogen cyanide (blood chemical agent)
AEL	allowable exposure limit
ATOFMS	aerosol time-of-flight mass spectrometry
B(a)P	benzo(a)pyrene
CARC	chemical-agent resistant coatings
CATI	computer-assisted telephone interview system
CB	chemical and/or biological
CDC	Centers for Disease Control and Prevention
CEHR	Center for Environmental Health Research
CG	phosgene (chemical choking agent)
CHPPM	Center for Health Promotion and Preventive Medicine
COT	Committee on Toxicology
CX	phosgene oxime (urticant chemical agent)
DEHP	di-2-ethylhexylphthalate
DNA	deoxyribonucleic acid
DoD	U.S. Department of Defense

EC_{50}	the airborne concentration of a chemical agent sufficient to produce severe effects in 50 percent of those exposed for 30 minutes
ED_{50}	the amount of liquid agent on the skin sufficient to produce severe effects in 50 percent of the exposed population
ELISA	enzyme-linked immunoassay
EPA	Environmental Protection Agency
FTIR	Fourier transform infrared
GA	tabun
GAO	General Accounting Office
GB	sarin
GD	soman
GPS	global positioning system
H	Levinstein mustard
HAP	hazardous air pollutant
HCB	hexachlorobenzene
HCH	hexachlorocyclohexane
HD	distilled mustard
HEPA	high-efficiency particulate air filters
HL	mustard-lewisite mixture
HN	nitrogen mustard
HVAC	heating, ventilation, and air-conditioning
H_2S	hydrogen sulfide
ICt_{50}	the incapacitating effect of a vapor or aerosol agent, which is the product of the concentration and exposure time, sufficient to disable 50 percent of a group of exposed and unprotected personnel at an assumed breathing rate (active or resting)
ID_{50}	the dose in mg or mg/kg of liquid agent expected to incapacitate 50 percent of a group of exposed unprotected personnel
IDLH	immediately dangerous to life and health
IMS	ion mobility spectrometry
IPT	Integrated Product Team
JCS	Joint Chiefs of Staff
JSMG	Joint Service Materiel Group
JWARN	Joint Warning and Reporting Network

L	lewisite
LCt_{50}	a measure of vapor or aerosol agent lethality, which is the product of the concentration and exposure time that is lethal to 50 percent of a group of exposed and unprotected personnel at an assumed breathing rate (active or resting)
LD_{50}	a measure of liquid agent lethality; the dose in milligrams (mg) of liquid agent or mg of agent delivered per kilogram (kg) of body weight expected to kill 50 percent of a group of exposed, unprotected personnel
MICAD	multipurpose integrated chemical agent alarm
MIST	Man-in-Simulant Test Program
NBC	nuclear, biological, chemical
NHEXAS	National Human Exposure Assessment Studies
NO_x	nitrogen oxides
NRC	National Research Council
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PCD	phosphorous chemiluminescence detector
PCE	Tetrachloroethylene
PCR	polymerase chain reaction
PD, ED, MD	double chlorinated arsines
P-DCB	1,4-dichlorobenzene
PEP	propellants, explosives, and pyrotechnics
PIC	personal information carrier
PIDS	photo-ionization detectors
PIRS	photoacoustic infrared spectroscopy
PVC	polyvinylchloride
R&D	research and development
RfC	chronic reference safe concentration
RfD	chronic reference safe dose
RNA	ribonucleic acid
SAW	surface acoustic wave
SBCCOM	Soldier and Biological Chemical Command

TEAM	total exposure assessment methodology
TIC	toxic industrial chemicals
TIME	total isolated by microenvironment exposure (monitor)
TCDD	2,3,7,8 tetetrachloro-dibenzo-p-dioxin
TCE	trichloroethylene
TWA	time-weighted average
VX	nerve agent
VX2	binary form of nerve agent VX
Vx	volatile nerve agent similar to VX
VOC	volatile organic compound
VOI	value of information

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